A revised list of seaweeds from Inhaca Island, Mozambique

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An updated compilation of marine algae for Inhaca Island, Mozambique is provided. The list comprises 205 species and infraspecific taxa (64 Chlorophyta, 23 Phaeophyta and 118 Rhodophyta). Nineteen of the seaweeds (9% of all records) have recently been placed into synonymy. The most common orders are Cladophorales (including Siphonocladales), Caulerpales, Gigartinales and Rhodymeniales. A $^{R+C}/_{p}$ ratio of 7.91 indicates strongly the presence of a tropical seaweed flora.

Keywords: Inhaca Island, Mozambique, sub-tropical seaweed flora, Indian Ocean, southern Africa.

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Introduction

The benthic intertidal seaweed flora of the east coast of southern Africa is documented and summarized in a number of publications (see Seagrief 1980, for Maputaland; Bolton & Stegenga 1987, for Transkei; Seagrief 1988, for the Eastern Cape; Bolton & Stegenga 1990, for Cape Agulhas; Bolton *et al.* 1991, for False Bay; Jackelman *et al.* 1991, for Cape Hangklip and Farrell *et al.* 1993 1994 for KwaZulu-Natal). In contrast, there is relatively little information available from the marine sublittoral zone of South Africa (but see Anderson & Stegenga 1989). However, Inhaca Island, Mozambique has attracted considerable attention from marine biologists. Isaac (1956) first investigated the marine algal flora of the island to obtain data relating to the distribution of seaweeds in the then Union of South Africa. Subsequent accounts of components of the marine flora appeared in Post (1957), Chamberlain (1958), Isaac (1958 1959) and Isaac and Chamberlain (1958). Pocock (1958) published the first checklist for the island. Additions to the list have been made by subsequent authors and particularly those associated with the International Indian Ocean Expedition of 1962 (viz. P. Silva 1959; Taylor 1967; Saenger 1971, 1973; Wollaston 1984 and Lambert *et al.* 1987). A biogeographic analysis of the island's seaweed flora was produced by Critchley *et al.* (1994). This present report represents the, as yet unpublished, species list used in that analysis). Separate lists of cyanobacteria in nine families containing 26 genera have been prepared for the island (Silva 1991a,b,c; Silva & Cuamba 1991). Further details on the general ecology of the island and adjacent Mozambique mainland can be found in Isaac (1957), Kalk (1959), Day (1974), Stephenson and Stephenson (1972) and Kalk (1995).

Inhaca Island forms part of a natural barrier between Maputo and the Indian Ocean, on the east of Maputo Bay, at 26°00'S latitude and 32°55'E longitude. The island falls under the influence of the southerly-flowing tropical Mozambique Current (Macnae & Kalk 1958; Macnae 1962, 1995), which runs along the continental shelf approximately eight kilometres off the eastern shore. The Mozambique Current has a core temperature of 25°C and its waters circulate in a mini-gyre towards Maputo Bay (De Freitas 1984).

Surface seawater temperatures on the east coast of Inhaca Island are usually about 24.5°C in contrast to the west coast where the shallower waters of Maputo Bay can be warmed considerably by insolation and reach temperatures in the upper 20's (Isaac 1937; Macnae & Kalk 1958, 1962; Kalk 1995). The island is also influenced, to some degree, by an erratic counter-current which may flow northward above the continental shelf (inside the Mozambique Current), bringing cooler waters to the east coast of Inhaca in winter. These phenomena result in marked temperature differences between the east and west coasts of the island. Similarly, differences in salinity exist between the eastern shores of the island (*c.*35.54%) and Maputo Bay shores, which receive freshwater influences (*c.*30–33.9%; Macnae & Kalk 1962).

The tidal range of extreme spring tides at Inhaca is 3.7 m, with an average of 3.3 m (Macnae & Kalk 1962), which compares with a maximum of less than 2.0 m for neighbouring South Africa (Bauer 1933). Tides are semi-diurnal, with two high and two low tides per day. Spring low tides occur between 09h30–13h00 (being more pronounced between 12h00–13h00) and 22h00–01h00, thus low water of spring tides (LWST) occurs during the heat of the day (mean annual air temperature range is 18.7–26.9°C; Macnae & Kalk 1958, 1962; Kalk 1995). The coincidence of low spring tides with the hottest part of the day is a factor that severely limits algal distribution above the mean tide level of the shore (Kalk 1954; Isaac 1958). Dense seaweed vegetation occurs on rocky shores only, such as those on the north-eastern end of the island. The wide belts of algae present are made more visible by the gently sloping shores and the large tidal range, exposing extensive tracts of beach at low water. Some of the island's sandy shores also provide varied substrata for colonization by sand-adapted algae (e.g. *Caulerpa* spp. and *Udotea* spp.; Isaac 1958). Isaac (1956) reported that there were reasons to believe there is more luxuriant growth of marine algae during the summer months but this statement remains uncorroborated.

This paper presents a revised list of marine algae for Inhaca Island, Mozambique. A number of these algae are of potential economic value and warrant further study as a source of colloid, secondary products (biologically active compounds) or food (Aingworth 1996; Vlachos *et al.* 1996; Gillespie *et al.* 1997).

Materials and Methods

Specimens of Inhaca Island seaweeds were either examined from 4% formalin-fixed material or herbarium vouchers which are deposited in The Albany Museum (GRA), Grahamstown, South Africa (M.A. Pocock collection); The Moss Herbarium (J), University of the Witwatersrand, Johannesburg, South Africa (C.E. Moss, collected 1938; W.E. Isaac collected 1954/56; R.L. Davidson collected, 1955; A.E.O. Mogg collected 1956–60 and 1979; F.D. Hancock collected 1960 and R.N. Pienaar and S. Sym collected 1989) and the Universidade Eduardo Mondlane (LMU), Maputo, Mozambique (J. de Koning and E.M.C. Groenendijk collected 1984).

References for identification include Jaasund (1976), Simons (1976) and Seagrief (1980, 1988); some species, however, required the use of other taxonomic publications: viz. Kylin (1938), Levring (1938), Papenfuss (1947), P.Silva (1959), Simons (1966), Lawson and John (1982), Norris and Aken (1985), Norris (1986, 1987a,b and c), Norris *et al* (1987) and Chamberlain and Keats (1994) were also consulted. Nomenclature, where appropriate, follows Seagrief (1984) and classification is taken from Seagrief (1980) and Wynne and Kraft (1981). Taxonomic and nomenclatural changes have been checked against Papenfuss *et al.* (1982), King and Puttock (1989), Huisman and Borowitzka (1990) and P.Silva *et al.* (1987, 1996). The taxonomy and nomenclature of P.Silva *et al.* (1996) have been adopted.

The nature of the seaweed flora of Inhaca island was assessed using the floristic ratio of Cheney (1977), viz.:

$$\frac{R + C}{P} = \frac{\text{No. of rhodophyte species} + \text{No. of chlorophyte species}}{\text{No. of phaeophyte species}}$$

With this calculation, a value of 3.0 indicates cold water flora, whilst values of > 6.0 indicate a tropical flora (Kapraun 1980, Mathieson & Penniman 1986).

Results

Based on published records and unpublished collections, a list of marine algae for Inhaca Island was compiled totalling 205 records (see Appendix 1). This total was made up of 24 genera of Chlorophyta (64 records in total), 13 genera of Phaeophyta (23 records in total) and 73 genera of Rhodophyta (118 records in total). The most common orders are Cladophorales (including Siphonocladales, 10 records) Bryopsidales (42 records), Dictyotales (10 records), Corallinales (13 records), Gigartinales (11 records) and the Ceramiales (60 records).The floristic ratio of Cheney (1977; $^{R+C}/_{p}$) gave a value of 7.91. Nineteen of the records have been placed into synonymy (after Silva *et al.* 1996, marked 'syn.*' in Appendix 1 next to the most recent name applied locally).

Discussion

The close link between seawater temperature and seaweed flora in southern Africa is well documented (Isaac 1937, 1938; Stephenson 1948; Macnae 1962; Brown & Jarman 1978; Bolton 1986; Bolton & Stegenga 1987, 1990; Farrell *et al.* 1993, 1994). The 7.91 floristic ratio for Inhaca Island is indicative of a decidedly tropical flora. A feature of the flora of the island is the large number of siphonous green algae, some of which also occur in KwaZulu-Natal, South Africa (Simons 1976; Seagrief 1980), Tanzania (Jaasund 1976), Madagascar and the Pacific Ocean islands (Pocock 1958; see also Farrell *et al.* 1994). The predominance of these siphonaceous green algae is probably a reflection of the large, sandy intertidal areas available to colonization on the east coast of southern Africa.

The tropical composition of the Inhaca seaweed flora may seem unusual initially, as the island is situated in the subtropics and is seasonally washed by a cooler counter current in winter, but the tropical influence is undoubtedly maintained by both the mini-gyres of the Mozambique Current and by warming of shallow waters in Maputo Bay on the west coast of the island (Macnae & Kalk 1962).

It is important to note that the absence of crustose coralline algae (Rhodophyceae) from this list, is due to lack of collecting (Dr Y.M. Chamberlain, pers. comm.). This component of the algal flora of Inhaca Island requires further attention. Likewise, subtidal collections could be expected to yield a number of new records (see Anderson & Stegenga 1989). Indeed, additions to the flora are likely to be most numerous in the Division Rhodophyta, thereby increasing the value of the Cheney (1977) floristic index, and further emphasising the tropical nature of the algal assemblage.

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Appendix 1 Revised list of seaweeds from Inhaca Island, Mozambique

		DIVISION CHLOROPHYTA
Chlorophyceae		
Ulvales	Monostromataceae	
		Monostroma Thuret sp.
	Ulvaceae	
		Enteromorpha compressa (L.) Nees
		E. cf. *prolifera* (O.F.Mueller) J. Agardh
		E. muscoides (Clemente y Rubio) Cremades (syn.**E. ramulosa* (J.E. Smith) Carmichael in W.Hooker
		Gayralia oxysperma (Kuetzing) Vingradova ex Scagel *et al.* (syn. **Ulvaria oxysperma* (Kuetzing) Bliding)
		Ulva uncinalis (Kuetzing) Montagne (syn.**U.capensis* Areschoug)
		U. rigida C. Agardh
Cladophorales	Anadyomenaceae	
		Anadyomene wrightii Harvey ex J.Gray
		Microdictyon kraussii J.Gray
	Cladophoraceae	
		Chaetomorpha antennina (Bory de Saint-Vincent) Kuetzing
		C. crassa (C. Agardh) Kuetzing
		C. cf. *linum* (O.F.Mueller) Kuetzing
		Cladophora prolifera (Roth) Kuetzing
	Siphonocladaceae	
		Boodlea composita (Harvey) Brand
		Boodleopsis pusilla (Collins) W.R.Taylor, Joly & Bernatowicz
		Struvea anastomosans (Harvey) Piccone et Grunow ex Piccone
		Valoniopsis pachynema (G. Martens) Boergesen
Bryopsidales	Bryopsidaceae	
		Bryopsis Lamouroux sp.
	Caulerpaceae	
		Caulerpa ambigua Okamura
		C. antoensis Yamada
		C. cupressoides (Vahl) C. Agardh var. *lycopodium* (J. Agardh) Weber-van Bosse forma *amicorum* (Harvey) Weber-van Bosse
		C. elongata Weber-van Bosse
		C. fergusonii G. Murray
		C. filiformis (Suhr) Hering
		C. lanuginosa J. Agardh
		C. lentillifera J. Agardh
		C. mexicana Sonder ex Kuetzing

Appendix 1 Continued

		C. peltata Lamouroux
		C. racemosa (Forsskal) J. Agardh var. *clavifera* (Turner) Weber-van Bosse var. *laetivirens* (Montagne) Weber-van Bosse var. *macrophysa* (Sonder ex Kuetzing) W.R.Taylor var. *racemosa* var. *turbinata* (J. Agardh) Eubank
		C. scalpelliformis (R.Brown ex Turner) C. Agardh var. *denticulata* (Decaisne) Weber-van Bosse var. *intermedia* Weber-van Bosse var. *scalpelliformis* Papenfuss & Egerod
		C. selago (Turner) C. Agardh
		C. serrulata (Forsskal) J. Agardh
		C. sertulariodes (S. Gmelin) Howe
		C. urvilleana Montagne
		C. webbiana Montagne var. *pickeringii* (Harvey & Bailey) Eubank
		C. zeyheri Kuetzing
	Codiaceae	
		Codium acuminatum O.Schmidt
		C. capitatum P.Silva
		C. cicatrix P.Silva
		C. duthieae P.Silva
		C. lucasii Setchell subsp. *capense* P.Silva
		C. megalophysum P.Silva
		C. mozembiquense P.Silva
		C. platylobium Areschoug
		C. pocockiae P.Silva
		C. prostratum Levring
		C. spongiosum Harvey
	Halimediaceae	
		Halimeda cuneata Hering
	Pseudocodiaceae	
		Pseudocodium de-vriesii Weber-van Bosse
	Udoteaceae	
		Avrainvillea Decaisne sp.
		Chlorodesmis hildebrandtii A. Gepp & E. Gepp
		Rhipidosiphon javensis Montagne (syn.* *Udotea javensis* (Montagne) A. Gepp & E. Gepp)
		Udotea orientalis A. Gepp & E. Gepp
Dasycladales	Dasycladaceae	
		Dascyladus ramosus Y. Chamberlain
		Neomeris dumetosa Lamouroux
		N. van-bosseae Howe
	Polyphysaceae	
		Acetabularia calyculus Lamouroux
		A. major G. Mertens (syn.* *A.moebii* Solms-Laubach)

Appendix 1 Continued

		DIVISION PHAEOPHYTA
Ectocarpales	Ectocarpaceae	
		Feldmannia irregularis (Kuetzing) G. Hamel
	Ralfsiaceae	
		Ralfsia expansa (J. Agardh) J. Agardh
Sphacelariales	Sphacelariaceae	
		Sphacelaria Lyngbye sp.
Dictyotales	Dictyotaceae	
		Dictyopteris delicatula Lamouroux
		D. longifolia Papenfuss (unpubl.)
		D. serrata (Areschoug) Hoyt
		Dictyota cervicornis Kuetzing (syn. * *D. pardalis* Kuetzing)
		D. dichotoma (Hudson) Lamouroux
		Lobophora variegata (Lamouroux) Womersley ex Oliveira
		Padina boryana Thivy
		Stypopodium zonale (Lamouroux) Papenfuss
		Zonaria subarticulata (Lamouroux) Papenfuss
		Z. tournefortii (Lamouroux) Montagne
Scytosiphonales	Chnoosporaceae	
		Chnoospora minima (Hering) Papenfuss
	Scytosiphonaceae	
		Colpomenia sinuosa (Mertens ex Roth) Derbes & Solier
		Hydroclathrus clathratus (C. Agardh) Howe
Fucales	Cytoseiraceae	
		Cystoseira myrica (S. Gmelin) C. Agardh
		C. trinodis (Forsskal) C. Agar&
		Hormophysa cuneiformis (J.Gmelin) P.Silva
	Sargassaceae	
		Sargassum crassifolium J. Agardh
		S. incisifolium (Turner) C. Agardh (syn.**S. heterophyllum* (Turner) C. Agardh)
		S. myriocystum J. Agardh
		Turbinaria ornata (Turner) C. Agardh
		DIVISION RHODOPHYTA
CLASS RHODOPHYCEAE		
SUBCLASS BANGIOPHYCIDAE		
Bangiales	Bangiaceae	
		Bangia Lyngbye sp.
Porphyridiales	Porphyridiaceae	
		Stylonema alsidii (Zanardini) Drew
SUBCLASS FLORIDEOPHYCIDAE		
Acrochaetiales	Acrochaetiaceae	
		Acrochaetium Naegeli (syn. **Audouinella* Bory de Saint Vincent) sp.
Nemaliales	Galaxauraceae	

Appendix 1 Continued

		Actinotrichia fragilis (Forsskal) Boergesen
		Galaxaura diesingiana Zanardini
		G. marginata (Ellis & Solander) Lamouroux
		G. obtusata (Ellis & Solander) Lamouroux
		G. rugosa (Ellis & Solander) Lamouroux
	Liagoraceae	
		Liagora ceranoides Lamouroux
		L. valida Harvey (syn.* *L.fragilis* Zanardini)
Gelidiales	Gelidiaceae	
		Gelidium pusillum (Stackhouse) Le Jolis
		G. reptans (Suhr) Kylin
		Pterocladia caespitosa (Kylin) R. Norris
	Gelidiellaceae	
		Gelidiella acerosa (Forsskal) J.Feldman & G.Hamel
Gracilariales	Gracilariaceae	
		Gracilaria arcuata Zanardini
		G. canaliculata Sonder (syn. * *G. crassa* Harvey ex J. Agardh)
		G. millardetii (Montagne) J. Agardh
		G. protea J. Agardh
		G. salicornia (C. Agardh) Dawson
Cryptonemiales	Halymeniaceae	
		Carpopeltis maillardii (Montagne & Millardet) Chiang
		Grateloupia filicina (Lamouroux) C. Agardh
Corallinales	Corallinaceae	
		Amphiroa beauvoisii Lamouroux
		A. fragilissima (Linnaeus) Lamoroux
		A. rigida Lamouroux
		Arthrocardia carinata (Kuetzing) Johansen
		A. flabellata (Kuetzing) Manza
		Cheilosporum cultratum (Harvey) Areschoug
		C. sagittatum (Lamouroux) Areschoug
		Choreonema thuretii (Bornet) Schmitz
		Haliptilon cubense (Montagne ex Kuetzing) Garbary & Johansen
		H. roseum (Lamarck) Garbary & Johansen (syn.**Corallina cavieri* Lamouroux)
		H. subulatum (Ellis & Solander) Johansen
		Jania intermedia (Kuetzing) P.Silva
		Leptophytum ferox (Foslie) Chamberlain & Keats
		Titanoderma corallinae (P.Crouan & H.Crouan) Woelkerling, Chamberlain & P.Silva (syn.* *Dermatolithon corallinae* (P.Crouan & H.Crouan) Foslie in Boergesen)
Gigartinales	Caulacanthaceae	
		Catenella caespitosa (Withering) L. Irvine
		C. nipae Zanardini
		C. subumbellata Tseng

Appendix 1 Continued

	Gigartinaceae	
		Gigartina Stackhouse sp.
	Hypneaceae	
		Hypnea cornuta (Kuetzing) J. Agardh
		H. musciformis (Wulfen) Lamouroux
		H. nidifica J. Agardh
		H. rosea Papenfuss
		H. spicifera (Suhr) Harvey
		H. tenuis Kylin
		H. viridis Papenfuss
	Mychodeaceae	
		Mychodea J.Hooker & Harvey sp.
	Phacelocarpaceae	
		Phacelocarpus cf. *complanatus* Harvey
		P. tristichus J. Agardh
Plocamiales	Plocamiaceae	
		Plocamium beckeri Schmitz ex Simons
		P. corallorhiza (Turner) Harvey
		P. glomeratum J. Agardh
		P. maxillosum (Poiret) Lamouroux
		P. suhrii Kuetzing
		P. telfairiae (W.Hooker & Harvey) Harvey ex Kuetzing
Rhodymeniales	Champiaceae	
		Champia compressa Harvey
		Chylocladia Greville sp.
	Rhodymeniaceae	
		Botryocladia madagascariensis G.Feldmann
		Gelidiopsis variabilis (J. Agardh) Schmitz (syn. **Ceratodiclyon variabile* (Greville ex J. Agardh) R.Norris)
		Rhodymenia natalensis Kylin
Ceramiales	Ceramiaceae	
		Anotrichium secundum (Harvey ex J.Agar&) Funari (syn.**Griffithsia secunda* J. Agardh)
		Antithamnion lherminieri (P.Crouan & H.Crouan) Bornet ex Nasr (syn.**A. antillanum* Boergesen)
		Callithamnion Lyngbye sp.
		Centroceras clavulatum (C. Agardh) Montagne
		Ceramium diaphanum (Lightfoot) Roth
		C. planum Kuetzing
		Crouania attenuata (C. Agardh) J. Agardh
		Gordoniella yonakuniensis (Yamada & T.Tanaka) Itono (syn.**Spermothamnion yonakuniensis* Yamada et Tanaka)
		Griffithsia confervoides Suhr
		G. secunda J. Agardh
		? *Mazoyerella* Gordon Mills & Womersley sp.

Appendix 1 Continued

	Pleonosporium caribaeum (Boergesen) R.Norris (syn.**Mesothamnion caribbaem* Boergesen)
	P. ? harveyanum (J. Agardh) De Toni
	Ptilothamnion polysporum Gordon-Mills & Womersley
	Spyridia cupressina Kuetzing
	S. filamentosa (Wulfen) Harvey
	S. hypnoides (Bory de Saint Vincent) Papenfuss
	Tiffaniella cymodoceae (Boergesen) Gordon
Dasyaceae	
	Dasya scoparia Harvey
	D. baillouviana (S.Gmelin) Montagne
	Heterosiphonia capensis Falkenberg
Delesseriaceae	
	Acrosorium maculatum (Sonder ex Kuetzing) Papenfuss
	Caloglossa leprieurii (Montagne) G.Martens
	Martensia elegans Hering
	Platysiphonia delicata (Clemente y Rubio) Cremades (syn.**Platysiphonia miniata* (C. Agardh) Boergesen)
	Taenioma nanum (Kuetzing) Papenfuss
Rhodomelaceae	
	Acanthophora spicifera (Vahl) Boergesen
	Amansia rhodantha (Harvey) J. Agardh (syn.* *A.glomerata* J. Agardh)
	Bostrychia moritziana (Sonder ex Kuetzing) J. Agardh
	B. radicans (Montagne) Montagne
	B. tenella (Lamoroux) J. Agardh
	Bryocladia densa Saenger
	Chondria armata (Kuetzing) Okamura
	Digenia simplex (Wulfen) C. Agardh
	Digeneopsis subopaca Simons
	Herposiphonia secunda (C. Agardh) Ambronn
	H. secunda (C. Agardh) Ambronn f. *tenella* (C. Agardh) Wynne
	Kuetzingia natalensis J. Agardh
	Laurencia columellaris Boergesen
	L. complanata (Suhr) Kuetzing
	L. flexuosa Kuetzing
	L. natalensis Kylin
	L. obtusa (Hudson) Lamouroux
	L. pumila (Grunow) Papenfuss
	L. tenera Tseng
	Leveillea jungermannioides (Martens & G. Hering) Harvey
	Murrayella periclados (C. Agardh) Schmitz
	Neurymenia fraxinifolia (Mertens ex Turner) J. Agardh
	Ophidocladus simpliciusculus (P.Crouan & H.Crouan) Falkenberg
	Osmundaria fimbriata (Lamouroux) R.Norris (syn.**Vidalia fimbriata* (Lamouroux) J. Agardh)

Appendix 1 Continued

	Placophora binderi (J. Agardh) J. Agardh
	Polysiphonia caespitosa (Pocock) Hollenberg (syn.**Falkenbergiella caespitosa* Pocock)
	P. incompta Harvey
	P. subtilissima Montagne
	Polyzonia elegans Suhr
	Pterosiphonia stangeri (J. Agardh) Falkenberg
	Rhodomelopsis africana Pocock
	Stictosiphonia tangatensis (Post) King & Puttock
	Streblocladia corymbifera (C. Agardh) Kylin